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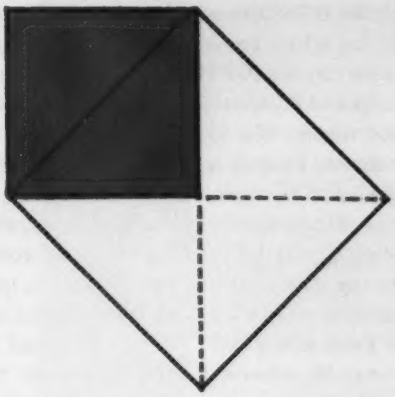


Not from teaching but from questioning

One of the most celebrated pedagogical feats of all time was performed, fittingly enough, by the most celebrated teacher of all time. Through a short series of questions, Socrates elicited from an ignorant slave boy the correct information that the square on the diagonal of a square is double the size of the original square.

This brilliant example of the Socratic method is to be found in Plato's *The Meno*. The dialogue illustrates several important characteristics of Socrates' line of questioning.

In the first place, it is apparent that Socrates has clearly in mind his objective, which is to lead the boy to solve this one particular mathematical problem. Every question is designed to lead him to do just that. In the second place, the boy is led step by step, in a clear sequence, from simpler to more complex facts or ideas. And the slave is forced to be active in the learning or "discovery" process: he must always respond, whether with a mere "Yes" or with some other answer.

Socrates is always alert to the boy's progress, seeing whether he is staying on the track. At one point, when the boy says "I don't understand," Socrates prompts him, gives him clues, reminds him of what he already knows. Finally (although Socrates himself denied that he told the boy anything), many or most of the questions actually impart information even as they elicit it.

At the conclusion of the demonstration Socrates tells his friend Meno: "So a man who does not know has in himself true opinions on a subject without having knowledge. At the present these opinions, being newly aroused, have a dream-like quality. But

if the same questions are put to him on many occasions and in different ways, you can see that in the end he will have a knowledge on the subject as accurate as anybody's. This knowledge will not come from teaching but from questioning."

* * * * *

Every great teacher since Socrates—and probably before, for all we know—has acted on the same insights about the nature of knowledge and the learning process. The good teacher tries to analyze his subject matter in such a way that he can present it in small, logical, coherent steps. He forces the student to be responsive, and he in turn is responsive to the student. He allows the fast student to move quickly and the slow one to move slowly. He asks leading questions. He observes closely the nature of the student's questions, grasping the error or truth the student is moving toward, heading him off from error, leading him on toward truth. The dialogue between a good teacher and a good student is as beautiful as a ballet or a baseball game.

This kind of dialogue at its best, however, requires a one-to-one relationship: one Socrates, one boy. Not every teacher is a Socrates. And it is the rare boy today who has a tutor all to himself. The irony is that at the very time when the pressure of numbers is making it less and less feasible to teach by this method, the research findings of social scientists, particularly behavioral psychologists, are confirming and extending the insights about the learning process shown by Socrates and countless others.

There is, however, a recent educational development which holds great promise of making possible on a mass scale the kind of individualized—or self—instruction that both teachers and psychologists believe to be the most effective. Carnegie Corporation has supported several research and experimental projects in this new field. Other foundations and, in particular, the federal government, through the Office of Education, have expended large sums in experimentation in the area.

The development is called variously (and the list is by no means inclusive) programed instruction, automated instruction, programed learning, self instruction, teaching machines. By whatever name, and in whatever form—for the material may be handled in any of a number of ways—the method consists essentially of presenting a carefully prepared sequence of curriculum material broken down into small steps. Each student works alone, at his own pace. Usually a question accompanies each step in the sequence, so that the student is forced to respond actively and is enabled to make a constant check on his understanding.

The material may be presented in a plain or fancy "machine," or in specially constructed books of one kind or another. There is, for example, a small machine with a window in the top which, at the pressure of a lever, reveals a sentence or question. The student writes his response, or answer, in a space that is provided; he then presses the lever again, is shown whether his response was correct; presses the lever again and the next step in the sequence appears. And there are "scrambled" textbooks in which, after completing a question on one page, the student is referred to another page to find out if his answer was correct, and so on.

At its best, the method resembles a conversation between a good tutor and a student. The tutor—or program—begins with a brief explanation and then proceeds to draw the student on by a series of leading questions. The tutor—or program—may hint at the answer if the question is difficult, but the student's progress depends on his own efforts and ability. If the student is apt, learning is rapid. If the student is not so apt, learning still takes place (which is more than happens in many a classroom), though at a slower pace.

Like most new developments, in education or other fields, programed instruction has been greeted with both fear and rejoicing. One of the fears—generally expressed as "Children should not be taught by *machines*"—is undoubtedly based on a misunderstanding of the technique. This fear would be better replaced by a wholesome skepticism as to how and when the method should be used, and both parents and educators should wait with patience until the time when more research and experimentation have provided answers to some important questions. For with the speed characteristic of our age, programed instruction has arrived on the scene almost before we have seen it coming; its premature exploitation on a large scale could mean that its rich and genuine promise would never be fulfilled.

B. F. Skinner and the Teaching Machine

BACK in the 1920's, Sidney L. Pressey, then professor at Ohio State University, actually designed several self-testing devices. The educational climate of the times was not hospitable to the innovation, however, and the idea remained dormant until the publication, in 1954, of a short article called "The Science of Learning and the Art of Teaching," by B. F. Skinner,* a noted psychologist at Harvard. In this paper Professor Skinner advocated the application of scientific knowledge to classroom procedures, and suggested the use of automated devices as a means of doing so.

* For this and other articles on programed instruction by B. F. Skinner and others, see A. A. Lumsdaine and Robert Glaser, *Teaching Machines and Programmed Learning: A Source Book* (Washington, D. C.: National Education Association, 1960).

It was not until three or four years later that the idea really began to catch on. Yet today materials are being prepared in subjects ranging from spelling to physics, at levels from prekindergarten to graduate school. Several school systems are using programed instruction on an experimental basis; some programs have already been published by commercial houses and many more are on the way.

Despite the considerable activity, this instructional technique is still in its infancy. Serious questions, with important implications for theory, remain at issue among responsible advocates of the method. One of the most prominent advocates is, of course, Mr. Skinner himself, whose influence has played a large role in the development of programed instruction.

In "The Science of Learning and the Art of Teaching" and subsequent papers Mr. Skinner charged (as have many others) that the findings of research on the learning process have not been applied in the classroom. "In spite of discouraging evidence to the contrary," he wrote, "it is still supposed that if you tell a student something, he then knows it." To acquire—or learn—behavior, a student must *engage* in behavior. In this, Mr. Skinner goes along with the "learning by doing" principle of the progressive educators. He also approves of their emphasis upon reward rather than punishment as a motivation for learning. But from what or whom, and when, is the reward—or "reinforcement," as the psychologists call it—to come?

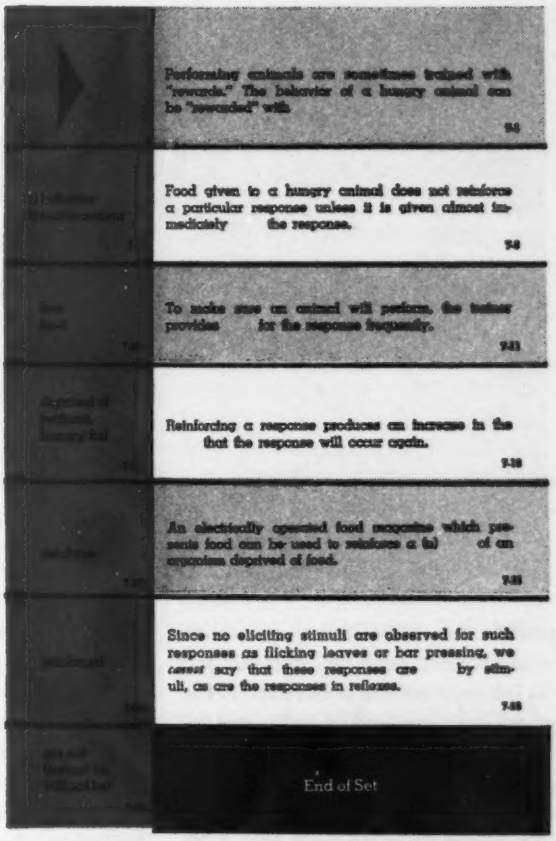
It is here that Mr. Skinner claims that much of modern educational practice puts the cart before the horse. It is true that a student must "pay attention" in order to learn. But simply attracting students' attention does not necessarily make them pay attention to what you want them to pay attention to. Mr. Skinner cites Erasmus' example of the Englishman who, in his desire to help his son learn Greek, had delicious cookies baked in the shape of Greek letters. There is no doubt that the boy learned to drool upon seeing a page of Greek text, but his understanding of the language was probably negligible. So also today's students may be attracted by textbooks printed in four colors and by handsome classroom displays, but whether their attention is actually drawn to what you want them to learn, say the Constitution, is questionable.

No, the reinforcement must come *after* the student has exhibited the desired behavior (learning), says Mr. Skinner, and it must be immediate and frequent. Furthermore, the human being does not need a cookie or some other tangible object as a reward; the mere knowledge that he is correct is a sufficient reinforcement to lead him to try to learn more.

The catch here is that he must be allowed to move at his own pace, and that he must be informed *immediately* that he is right. It is difficult to provide these conditions in the classroom, crowded or uncrowded.

"Holding students together for instructional purposes in a class is probably the greatest source of inefficiency in education," says Mr. Skinner. The ordinary — or even extraordinary — teacher cannot possibly know whether every child in the class is grasping each step of instruction. At best the child may find out 24 hours later, after the teacher has had a chance to go over his workbook, that he was right or wrong. At worst, weeks may go by, until examination time. By then all that is apparent is that somewhere the student got lost, but where or when or why is almost anyone's guess.

Programed instruction can, of course,


Performing animals are sometimes trained with "rewards." The behavior of a hungry animal can be "rewarded" with
Food given to a hungry animal does not reinforce a particular response unless it is given almost immediately the response.
To make sure an animal will perform, the trainer provides for the response frequently.
Reinforcing a response produces an increase in the that the response will occur again.
An electrically operated food magazine which presents food can be used to reinforce a(n) of an organism deprived of food.
Since no eliciting stimuli are observed for such responses as flicking leaves or bar pressing, we *cannot* say that these responses are by stimuli, as are the responses in reflexes.
End of Set

The above page from a self-teaching text illustrates one kind of programed textbook. On the left-hand side are answers to questions that appear on the preceding page of the book and on the right-hand side are new questions, for which answers are found on the next page of the book.

From J. G. Holland and B. F. Skinner, The Analysis of Behavior: A Program for Self-Instruction, *p. 42. Copyright 1961 by McGraw-Hill Book Company, Inc.; New York. Used by permission of the publishers.*

No.	1.	The numbers we use to count with are called 'counting numbers' or 'natural numbers'. 0, 1, 2, 3, etc. are natural numbers. ½ is not a natural number. Is ¾ a natural number? ☐ *(Yes or no?)*
natural	2.	0, 1, and 2 are natural numbers. 3, 4, 71, and 10,001 are also ☐ numbers.
natural	3.	0 is a ☐ number.
¾	4.	Which of the following is not a natural number? ☐ 0, 12, 627, 2+3, ¾, 5−1
8001	5.	Which of the following is a natural number? ☐ ⅔, 10.2, 4¼, 8001, $^{8001}/_{4378}$

The program samples above and on page 5 were taken from Modern Mathematics: A Programed Textbook, *Course 1, Book 1, chap. 2, by Lewis D. Eigen, Jerome D. Kaplan, and Ruth Emerson (developmental edition). Copyright 1961 by Science Research Associates, Incorporated; Chicago. Used by permission of the publishers.*

provide the immediate and frequent reinforcement that Mr. Skinner and his followers believe is essential. A few years ago, he and a colleague at Harvard programed a course in psychology, to be used in a teaching machine; many courses in many subjects have been programed since, both by Mr. Skinner's group at Harvard and by others. Mr. Skinner received Carnegie support for some of his research.

The Program—or Programs

THE heart of programed instruction is the program itself, and the writing of a program is an art. It may also prove to be one of the best teacher-trainers in the world, for it forces the programmer to analyze his subject matter closely and to have his objectives clearly in mind. Each question must be constructed in such a way that the student *must* understand the material properly if he is to answer correctly.

In the Skinnerian school of thought, the "perfect" program would be written in such a way that almost every student would eventually be able to complete it without making a mistake. There are several reasons for this, one being that, if the student is wrong, there is no reinforcement or reward. Also there is the possibility that the mistake, once it has been written down, may remain in the student's mind. And since the object is to get the student to behave properly (that is, respond with the correct answer), the way to teach him to do so is to ensure that he writes the correct answer.

For somewhat the same reasons, the Skinnerians do not believe that a program should contain multiple choice questions. The student must construct, rather than merely choose, a response, since that is the kind of behavior that will eventually be useful to him.

Some eminent psychologists believe that these views still remain to be proved; others disagree entirely. Is learning really inhibited by the making of a mistake? Is it not desirable to anticipate a plausible error and then point out to a student how he came to make it? Thus programs can be constructed that are quite different from those of Mr. Skinner and his followers, in that they provide for "branching" or the presentation of different material depending on a student's answer to a question. Thus, for example, if a student chooses a wrong answer from a multiple choice question, he may receive an immediate explanation as to why his answer is wrong, with perhaps a hint as to how he arrived at it, and then can be sent back to try again. Or if a student demonstrates by one or more wrong answers that he does not understand some aspect of the material, the program may branch to tutor him in his weak area or to direct him to prerequisite instruction. Another kind of program may direct him to jump ahead to new or more difficult problems when his answer to a question shows that he has already mastered the level at which he is working.

The important question as to whether the student must always be right is not resolved, and it seems that there is not yet enough evidence to support either side conclusively. It is, of course, possible that both methods are good: that learning can take place efficiently under either.

There is also some debate over whether reinforcement must be as frequent as Mr. Skinner claims. Some people question whether it is necessary that a student make a definite, overt response to every item of information.

Just how small each step must be is also still in doubt. And there are those who say that some form of teaching machine should always be used; others say programed textbooks are just as good or better.

In short, many questions still remain. What is needed is more experimentation, more research, more careful evaluation. One way to achieve these things is through the construction and testing of programs.

Some Carnegie-Supported Experimentation

An early entrant into the programing field was the Collegiate School, an independent primary and secondary school in New York City. The development of its work provides a good example of the speed of growth of the field in general.

About four years ago, a teacher at the School developed a program in modern mathematics: "Sets, Relations, and Functions."* (This work was supported by the Fund for the Advancement of Education.) The math course proved to be a very useful addition to the School's curriculum, and programing was started in physics, foreign languages, and English. More and more attention, from both educators and commercial interests, was drawn to the work of the group, and last year, with Carnegie support, the group formed the Center for Programed Instruction, a nonprofit educational organization, headed by P. Kenneth Komoski, a former teacher at Collegiate School. It maintains ties with the School but handles all of its own business activities.

The primary purpose of the Center is to develop curriculum materials of high quality for use in schools. More than 20 different programs are now under development—some nearing the point of publication, others available for experimental purposes, and still others only in the beginning phases.

In addition to constructing programs, the Center carries on applied research into how the quality of materials might be improved, and how they may best be used in the schools. Accordingly it is cooperating with several school systems in carrying out experimental try-outs of materials.

The Center also helps disseminate accurate information about programed instruction to the interested public. It now issues free of charge a small bulletin, "Programed Instruction," which gives news about the method and summarizes the results of research. As part of its educational work the Center last summer, in cooperation with several universities in different parts of the country, conducted workshops for teachers and school administrators.

Although most experimentation has been directed at programing the basic subjects for the elementary and secondary grades, work has also been done at other levels. One of the early Carnegie grants in the field was to Hollins College, for programing the two-year beginning sequences in French, German, Spanish, and Russian. At an even more advanced level, the Dartmouth Medical School received Carnegie support for programing portions of material in anatomy, physiology, biochemistry, pharmacology, pathology, and microbiology.

The most recent Carnegie grant in the field went to Harvard University, for work to be directed by an all-University Committee for Programed Instruction. Harvard's work will involve both the development and testing of programs and research on all aspects of this form of instruction.

Work is now beginning in programing for French and chemistry at the college level. At the pre-college level, Harvard will work through the already existing School and University Pro-

*By Lewis D. Eigen, published by the Center for Programed Instruction, 365 West End Avenue, New York 24.

0	166.	When we add trips (directed numbers), we always start at '☐'.
+7 *or* (+7) *(+7 is better.)*	167.	(+6) + (+1) = ☐. *(Hint: Draw a scale and work out the two trips if you have to.)*
+9 +11 +12	168.	(+4) + (+5) = ☐. (+2) + (+9) = ☐. (+8) + (+4) = ☐.
If your answer was three, go directly to frame 176. If your answer was not three, go to the next frame.	169.	The last frame had three problems on it. How many did you get right? ☐

gram for Research and Development (SUPRAD). The public school systems of nearby Newton, Lexington, and Concord have joined with the Harvard Graduate School of Education in a common effort to meet some of the important problems with which American education is faced. SUPRAD has already developed and experimented with a couple of teaching machine programs: one in spelling at the elementary school level, and one in junior high mathematics.

Quality Control

DESPITE all the research and experimentation in the field, there is so far still no way of judging the quality of a given program other than by using it on students. In short, there are no established criteria or standards by which such programs may be judged. Is it possible to formulate what might amount to a quality control check?

A recent Carnegie grant to explore this matter was made to the Educational Testing Service. It will attempt to find ways in which a given program may be evaluated in terms of answering three basic questions. First, is the substance of the course that has been programed up to date, and is it worthwhile in the judgment of authoritative opinion in that particular field? Second, is the programing itself compatible with requisite standards of technical excellence? And finally, what evidence is there that the programed material is effectively communicated to students?

Creativity and Automated Instruction

ONE over-riding question must surely loom in the mind of the reader. Is the beginning and end of education to be found in the acquisition of subject matter? There can be no doubt that this is the assumption, implicit or explicit, which underlies much of the developmental work on programed instruction. But what about some of the broader aims of education—the development of creative abilities, of critical thinking, of imaginative problem-solving? Does automated instruction have a role to play in achieving these aims, or may it perhaps actually militate against them?

This highly important and extraordinarily complicated question is the subject of basic research which will be directed by Professor Richard S. Crutchfield under a Carnegie grant to the University of California at Berkeley. Mr. Crutchfield, who is a psychologist, participated in the research on creativity described in the July issue of the *Quarterly*.

Mr. Crutchfield believes it is possible that automated methods of instruction can, if properly conceived and designed, be deliberately aimed at fostering the individual's capacity and readiness for creative thinking and problem solving. He therefore is devising a multi-faceted research program in which he is attempting to determine how programing techniques can be used to stimulate several different features of the creative process. He will try to construct procedures which will elicit from individuals a larger volume and range of solution "ideas," which will aid the student to increase his freedom from a single approach to problem solving, and encourage intuitive as contrasted to sense-dominated approaches to problems.

The Future

THE implications of programed instruction are so wide and so deep that they defy quick summary. The questions raised range from the technical (What kind of machine is best? How big should the steps be?) to the most profound: (What are the aims of education?).

The development does hold peril as well as promise. The first and most obvious danger is that if bad programs gain currency (and qualified observers say that bad programs are indeed available) the entire method itself may be discredited, with a resulting loss to education. There is the corresponding danger of "overselling" the method before all evidence is in, with a similar loss of confidence in the technique. There is still too little known about

whether students learn material *better* through programed instruction than in the conventional way, although there is some proof that they learn it *faster*. Very little is known about how long students taught by this method remember what they have learned. Research will soon provide answers to some of these questions, and will indicate what may reasonably be expected.

There is the danger that, under public pressure for dramatic "reforms" in education, some school administrators will succumb to the temptation of purchasing "hardware" prematurely in the hope of demonstrating that they are alert and up to date. If the hardware is shoddy, they—and their schools—will simply be stuck with nothing except a big bill.

Another immediate problem is the question of *what* to program. Probably the most significant thing that has happened in American education in recent years, apart from the development of programed instruction itself, is the great attention being paid to curricular revision. Work on reforms in mathematics and some of the sciences is now nearing completion; there are stirrings in other fields. The decision to program traditional mathematics or biology, for example, could hold back needed change for years. On the other hand, is it wise to program the "new" courses before their value has been proved? This presents a knotty problem for conscientious programmers and publishers.

This genuine and debatable problem is very different from another danger: that programmers or publishers who are not so conscientious will simply rush to put into programed form textbooks or courses which are already known to be poor or inadequate. Even this, deplorable as it is, should not destroy the movement as a whole. As one eminent psychologist says: "There've always been plenty of bad textbooks around, so I guess the system will survive a few bad programs."

The promise of programed instruction, however, far overshadows its peril. There are so many important values on the credit side that it is unthinkable that American educators will permit a development of such promise to be blighted by wholly—or at least partially—avoidable pitfalls.

Probably the most important value—or at least the one on which there is the greatest unanimity of agreement—is that the method makes it possible for each student to move at his own pace. A good program, too, is certainly better than a poor or mediocre teacher. And although more experimentation is needed before it will be clear exactly how many and what subjects may be well taught by the method, it is already quite apparent that it is an unusually efficient and effective way of teaching certain parts of certain subjects, such as mathematics and languages.

The technique is a potentially useful device for educational research. It forces strict analysis of subject matter and a definition of objectives, and makes it possible to know exactly when and where students miss a point. Consequently programs can be constantly improved.

The role of the teacher can also be improved. Freed from much routine and tiresome labor, the teacher may begin to function, as Mr. Skinner writes, "not in lieu of a cheap machine, but through intellectual, cultural, and emotional contacts of that distinctive sort which testify to his status as a human being."

The ultimate potentialities of programed instruction are still unknown. One day, probably soon, today's teaching machines will be seen as primitive. Computers, with their immense capability for storing information and for making instantaneous responses, will offer immense possibilities as the field unfolds. And whatever form or forms programed instruction may ultimately assume, it is certain that we shall be put through a valuable exercise, for the further development of the field will require a more rigorous definition of the educational goals we seek than we have yet been able or willing to make.

Appropriations

GRANTS amounting to $184,500 were voted during the final quarter of the fiscal year 1960–61, which ended September 30. The total appropriations for the year amounted to $10,593,425.

The income for the year was $10,930,000, of which $698,200 had

been set aside to meet commitments, including those for teachers' pensions, incurred in previous years. It is the Corporation's policy to spend all income during the year in which it is received.

New Treasurer

JAMES W. CAMPBELL became treasurer of Carnegie Corporation on October 1, succeeding C. Herbert Lee, who retired September 30. Mr. Lee had been treasurer of the Corporation since 1937.

Mr. Campbell was born in Scotland and educated there. He came to the United States at the age of 20. A senior accountant with a New York accounting firm, Mr. Campbell joined Carnegie in 1933 as an accountant and assistant to the comptroller. He was appointed assistant treasurer in 1953 and associate treasurer in 1957.

Grants in Progress

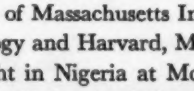
Reflecting the increasing interest in Africa, the Library of Congress opened an Africana Section in March, 1960. In just one year of operation, the Library reports remarkable growth in the Section's acquisitions, bibliographic work, and reference services.

To date the Section has concentrated on bibliographic activities. It has published Part I of *Official Publications of British East Africa; The East Africa High Commission and Other Regional Documents* and *Official Publications of French West Africa, 1946–1958.* This fall it will publish *Serials for African Studies* and, in cooperation with the Boston University library, it is preparing for publication a checklist of Ph.D. dissertations on African subjects accepted by U.S. and Canadian universities. Other works are on its publications calendar.

The Section recommended the acquisition of about 1,200 publications this year, some of which were for the growing collection of reference works, including bibliographies, directories, atlases, and guides. Dr. Conrad C. Reining, the head of the Section, also visited Europe, Senegal, Guinea, Sierra Leone, Ghana, Nigeria, the Congo Republic, and the Union of South Africa to purchase books and periodicals and to arrange for the regular receipt of new materials.

Among its many other activities, the Section helped almost 1,000 persons who called on it for assistance.

In its report to the Government of Nigeria, the Commission on Post-Secondary and Higher Education (the "Ashby" Commission) recognized that Nigeria's great efforts to achieve its 10-year educational goals would require financial assistance from sources outside the country. The Federal Government therefore has set up the Coordinating Committee for External Aid to Education to seek funds from abroad and to match offers of aid with projects in the nation's educational development plan. The Bureau for External Aid, recently established in the Federal Ministry of Education to serve as the secretariat for the Coordinating Committee, has employed as one of its two undersecretaries Donald J. Eberly, formerly on the administrative staff of Harvard University. A graduate of Massachusetts Institute of Technology and Harvard, Mr. Eberly has taught in Nigeria at Molusi College and at University College, Ibadan.



Before this academic year ends, 10 gifted senior Yale men who are *not* planning a career in college-teaching will be invited to accept Yale-Carnegie Teaching Fellowships. Those who agree will next year conduct introductory courses and discussion sections in their fields and take one or two graduate courses. Of the 27 men who have completed their fellowships since the program began in 1958, more than 75 per cent now plan teaching careers.

Carnegie Corporation of New York Quarterly

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Helen Rowan, *Editor*

Each issue of the Quarterly describes only a few of many Carnegie-supported projects in a variety of fields. Full listings of all the Corporation's activities are contained in its annual reports, which usually are published in January.

Carnegie Corporation of New York is a philanthropic foundation created by Andrew Carnegie in 1911 for the advancement and diffusion of knowledge and understanding. It has a basic endowment of $135 million and its present assets, reckoned at cost value, are approximately $221 million. Approximately 7 per cent of the income may be used in certain British Commonwealth areas; all other income must be spent in the United States.

The Corporation is primarily interested in higher education and in certain aspects of international affairs. Grants are made to colleges and universities, professional associations, and other educational organizations for specific programs. In higher education, these include basic research, studies of educational developments, training opportunities for teachers and administrators, and other educational projects of an experimental nature. In international affairs, the Corporation is concerned primarily with research and training programs which promise increased understanding of the problems the nation faces and which provide better selection and training of young men and women who must deal with these problems.

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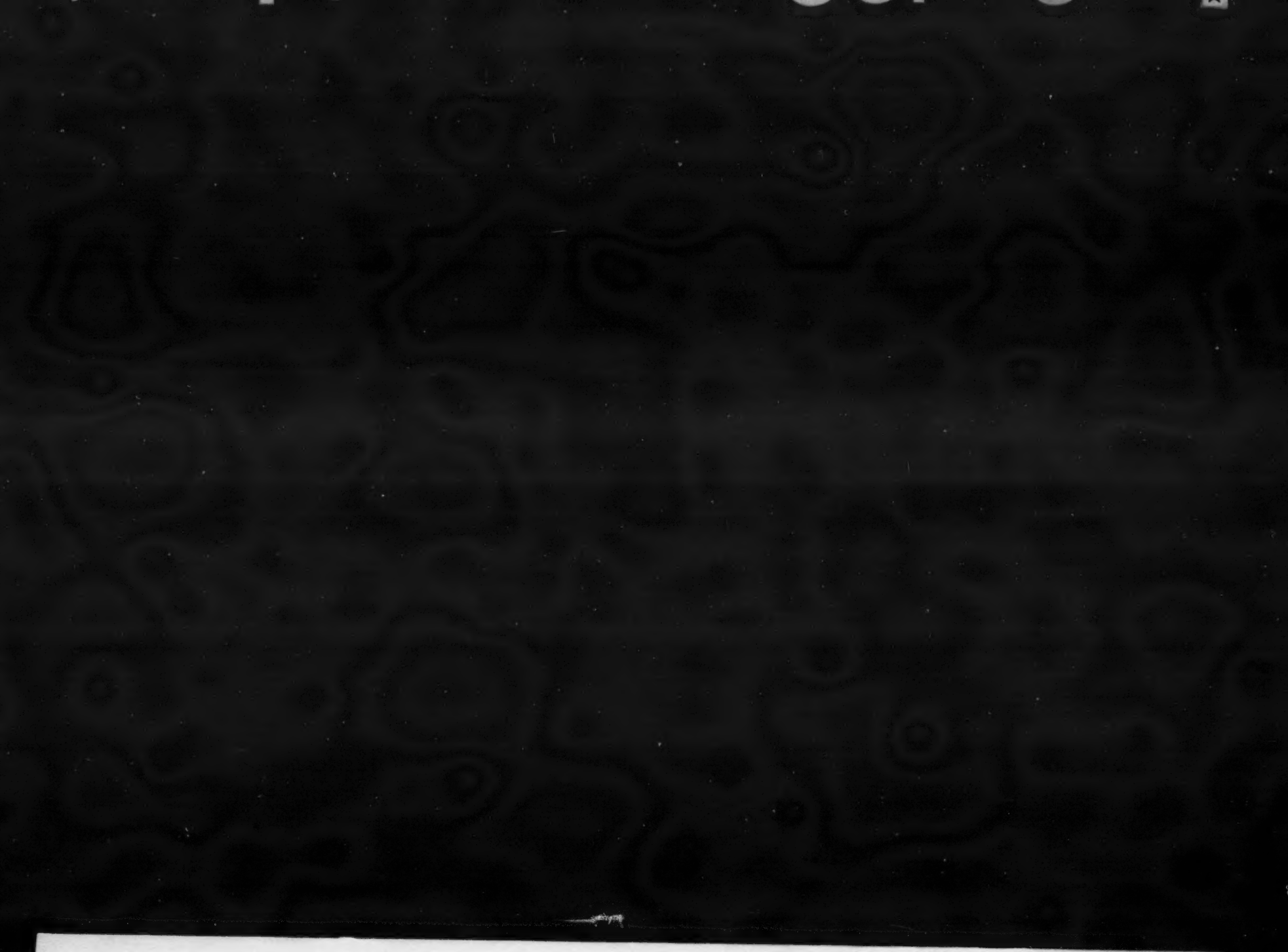
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